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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Project	Date	Author

TITLE

THE COMPOSITION OF INSECT INFESTATIONS IN PONDEROSA AND JEFFREY PINES LASSEN NATIONAL FOREST, CALIFORNIA

Season of 1940 and 1941

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Season of 1940 and 1941

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THE COMPOSITION OF INSECT INFESTATIONS IN PONDEROSA AND JEFFREY PINES LASSEN NATIONAL FOREST, CALIFORNIA

Season of 1940 and 1941

Studies of the composition of forest insect infestations in the stems of ponderosa and Jeffrey pines have been maintained by the Bureau of Entomology and Plant Quarantine since 1931 (5). These studies were undertaken to secure more comprehensive information on the seasonal infestation conditions than was obtainable from basal examinations of standing trees alone. To this end it has been the practice to fell a series of infested trees in the autumn of each year, making detailed stem analyses of the relations between the insect species attacking the trees. The results of these annual cruises have been presented in several station reports (1-2, 5-7).

Composition analyses have been made on trees of several forest areas (5). Since 1937 the investigations of the eastside areas have been restricted to the Modoc National Forest and to the Lassen National Forest in the vicinity of the Black's Mountain Branch of the California Forest and Range Experiment Station. It is the purpose of this report to summarize the results of the 1940 and 1941 stem analyses made in the Lassen area.

OBJECTIVES

The studies of species relations in the infestations of ponderosa and Jeffrey pines were begun because of a need for more knowledge of such phenomena than had been obtained from the usual field examinations of standing trees. Attention was directed to four specific objectives:

(1) To determine what insect species had attacked the trees.

(2) To determine the sequency of the attacks of different species on the trees and their inter-relationships in the infestations.

(3) To determine the relative frequency of the different species, and the fluctuations in their numbers from year to year.

(4) To discover the infestation patterns characteristic of the different years.

LOCATION OF TREES AND METHODS OF ANALYSIS

During 1937 to 1939 two areas of differing stand characteristics were sampled. Infested trees of the fringe forest comprised one sample, with trees in the interior forest areas of better site furnishing the second.

In these years the trees were located by cruising a 5-chain road strip from a vehicle. In 1940 sampling of the fringe forest was much reduced because of the scarcity of infested trees in that area. Instead, trees were taken largely from the better sites near the Black's Mountain Experimental Forest, and near Harvey Valley. In 1941, because of the low infestation level, all sampling was confined to trees in the experimental area, the trees having been located previously during the autumn insect loss cruise of the area.

Collection of data from the felled trees has followed a set form. Records are made of the insect species and the developmental stages present in the boles. Variations in the infestation composition in different parts of the stems are observed, and measurements taken of the diameters and lengths of the bole sections bearing the different infestation types. Special conditions of topkilling, strip-killing, green tops, and other features are included in the records for each tree, all data being recorded on stem analysis forms.

In the preparation of the data for the reports two alternate methods have been followed. The first has used computations in square feet of the total bark areas infested by different species for purposes of presenting the results of the studies. This was used in two reports (1 and 5). By the other method the data have been expressed on a simple tree basis, in percentages of trees infested by different species and combinations of species (2 and 7). This form for the expression of results is employed in the present report.

The size of the sample, i.e., the numbers of trees felled, has varied from year to year. The original plan called for the examination of about 100 trees each autumn, including both Jeffrey and ponderosa pines. The early onset of winter in 1940 and the scarcity of trees in 1941, however, made it necessary to sample smaller numbers. In 1940 all trees felled were ponderosa pine. In 1941 both Jeffrey and ponderosa pine were included in the sample. The numbers of trees examined in two years are given in Table 1.

Table 1. Size of Samples for Composition Analysis - 1940 and 1941

Year	Single Trees	Group Trees	All Trees
1940	22	32	54
1941 Ponderosa Pine	24	12	36
1941 Jeffrey Pine	8	5	13
1941 All	32	17	49

CHARACTERISTICS OF THE INFESTATIONS - 1940-1941

Infestation levels

The infestation was quite uneven over the Lassen area in 1940. In the lower fringe types of Site IV quality infested trees were scarce. Road-stripping of several miles of the fringe revealed but five single trees. This condition was in marked contrast with that of 1939, when infested trees were numerous, with many tree groups containing 2 to 10 trees.(1). In the interior forest in 1940 there were numbers of infested trees both singly and in groups. Because of these circumstances sampling was confined almost entirely to trees on the better sites of the interior forest area.

In 1941 the tendency towards a lower infestation level which was first evident on the fringe in the previous year extended itself over most of the forest area (4). Losses were the lowest of several years. Infested trees carrying overwintering brood were so few that road stripping was abandoned. It was necessary instead to rely upon trees located by the intensive autumn loss cruise in the Black's Mountain Experimental Forest.

Grouping tendencies

Differences in grouping tendencies were observable in the two years. In 1940 no "winter" groups were found in the fringe forest. In the interior forest, however, groups of four or five trees were common. Thirty-five, or 59 percent of the trees analyzed, were taken from groups.

In 1941 tree groups were much more infrequent. For the most part they contained two trees only. Two groups of larger size were found. One was the product of two seasons' attacks. The other was a new 1941 winter group of four trees. Seventeen trees, or 35 percent, of the total number felled were taken from groups.

Tree size

An indication of the size of trees most subject to attack in the two years is afforded by an examination of the average volume in board foot measure of the infested trees of each year. These are given below:

Year	Single Trees Av. Vol. B.M.	Group Trees Av. Vol. B.M.	All Trees Av. Vol. B.M.
1940	1,078	1,164	1,129
1941	1,223	887	1,106

The average volume per tree differed by only 23 feet in the two years, being a little over 1,100 board feet each year. This is almost equivalent to the volume of a tree 30 inches in diameter at breast height.

Comparison between the 1940 and 1941 single trees, and between the 1940 and 1941 trees of groups show greater differences, although their significance is not clear. The average volume of single trees appears to have increased slightly from 1940 to 1941. The average volume of trees of groups, however, decreased from 1940 to 1941.

Comparison between the average size of single trees and trees of groups in 1940 shows a greater volume in favor of the group trees. This is somewhat unexpected, as past experience has indicated that the average volume of trees of groups is usually lower than that of single trees. In 1941 the average size of single trees is more than 330 feet per tree larger than that of group trees.

The occurrence of previously topkilled trees

The occurrence of previously topkilled trees in the samples of the autumn loss showed a noticeable change from 1940 to 1941. In 1940, 28 percent of the trees had suffered topkilling previous to the year of death. In 1941, 39 percent of the trees were previously topkilled. This increase probably is a reflection of the change during the two year period from an epidemic to an endemic infestation, resulting in 1941 in a concentration of insect attacks on the more decadent types of trees.

Species relations

When infested trees are felled and examinations made along the length of the boles, the attacks of more than one species of insect usually are found. Such circumstances require an analysis of each infestation on a uniform basis in order to classify systematically the types of infestation that are encountered. The chief criterion of classification employed in the composition studies has been that of the timing of the attacks of the different species, or the determination of which species have first become active in the sequence of attacks leading to the death of the trees. A second criterion is the combination of species in each infestation. On these two bases the infestations may be characterized.

In making such analyses it has been realized that other factors than the entomological may have initiated the succession of events resulting in the death of the trees. Because of the difficulties surrounding attempts to recognize and evaluate such factors at the time of tree death, no attempt has been made to include a study of these. However, their possible importance in predisposing trees to insect attack and in influencing the types of infestation that are developed is acknowledged.

In the infestation of ponderosa pine of the Lassen area seven insect species are of common occurrence. These are:

Dendroctonus brevicomis Leconte
Melanophila californica Van Dyke
Dendroctonus monticolae Hopkins
Ips emarginatus (Leconte)
Melanophila gentilis Leconte
Ips oregoni (Eichhoff)
Dendroctonus valens Leconte

In 1940 four of these species were found to have been the initiators of attack sequences in the trees (Table 2). These were D. brevicomis, M. californica, D. monticolae, and I. emarginatus. In 1941 in addition to these four species, M. gentilis also initiated an attack sequence in one tree. From one year to the next there were differences in the frequency of occurrence of the different species, the differences being related to the changes in the character of the infestation during the two year period.

Table 2. Occurrence of Insect Species in Infested Ponderosa Pines (in percents of total)

	Primary		Secondary		Total Occur.	
Species	1940	1941	1940	1941	1940	1941
D.b.	57.4	44.4	35.2	33.3	92.6	77.8
M.c.	31.5	33.3	14.8	16.7	46.3	50.0
D.m.	7.4	11.1	13.0	19.4	20.4	30.5
I.e.	1.9	2.8	7.4	30.6	9.3	33.3
M.g.	-	2.8	3.7	-	3.7	2.8
I.o.	-	-	22.2	19.4	22.2	19.4
D.v.	-	-	1.9	13.9	1.9	13.9
Unkn.	1.9	5.6	-	-	1.9	5.6
Total	100.0	100.0	100.0	100.0	-	-

Dendroctonus brevicomis in both years was the most important of the several species having primary roles in the infestations. In 1940 57 percent of the trees were first attacked by D. brevicomis. By 1941, however,

the number of primary attacks had dropped to 44 percent. This drop in activity is in agreement with the general reduction in the infestation of this species during the two years. As a secondary, the occurrence of the species changes but little in the two years.

During the examination of trees in 1940 the impression was gained that the overwintering broods of D. brevicomis were to a large extent the product of the late summer generation of beetles. It appeared that early onset of cold weather held the late summer generation in the trees, and much reduced the number of new attacks of the winter generation. In 1941 trees with new attacks of the autumn generation seemed to make up a greater percentage of the total. A comparison of the stages of development of the infestations in the two years suggests that these conditions actually prevailed:

Table 3. Brood Age in Trees Infested with Dendroctonus brevicomis

Year	Newly Infested		Young Brood		Fullgrown Brood		Partly Abandoned		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
1940	2	4.0	7	14.0	33	66.0	8	16.0	50	100.0
1941	8	28.6	8	28.6	2	7.1	10	35.7	28	100.0

It will be observed that 66 percent of the trees contained fullgrown broods of D. brevicomis in 1940, as compared to 7 percent in 1941. Newly infested trees, trees with young broods, and partially abandoned trees, however, made up a much greater part of the infestation in 1941. This would seem to indicate a greater emergence from the summer trees took place in the current year, permitting the establishment of a new generation in the autumn.

Melanophila californica was the second most important species in initiating active infestations in the two years. In 1940 it was first to be active in 32 percent of the trees. In 1941 it appeared to be primary in 33 percent of the trees. M. californica occurred in small numbers and as small "incipient" larvae in several additional trees each year. Since the larvae were in small numbers and had not entered the more aggressive fast-growing condition, the death of the trees was not ascribed to the attacks of the species, even though it was first in entering the trees. An additional 15 percent of the trees carried infestations of this character in 1940, and 17 percent in 1941. M. californica infestations did not appear to be especially aggressive in either year.

Dendroctonus monticolae was third as a primary species in both years, but it attacked much smaller percentages of trees than the other two species. It initiated attacks in 7 percent of the trees in 1940 and in 11 percent in 1941. The rises in both its primary occurrence and secondary occurrence from one year to the next agrees with general field observations of an increase in the numbers of this species in the current year. It will be observed that the species had a greater occurrence each year as a secondary than as a primary. This is indicative of the general role of the species in the forests of the "eastside" areas.

Ips emarginatus was found initiating attacks in one tree each year. As a secondary, however, the species was more abundant. It occurred in 7 percent of the trees in 1940, and in 31 percent of the trees in 1941. This increase in its occurrence from 1940 to 1941 was supported by field observations. The species was the second most abundant bark beetle in the area in 1941, the populations appearing to be at their highest level in several years. This phenomenon, as well, also, as the increase in the abundance of D. monticolae and D. valens, perhaps was related to the changes in the activity of D. brevicomis. With the drop in the infestation of D. brevicomis from 1940 to 1941, many partially infested trees were left with green butts or tops. These uninfested portions of the boles were attacked heavily and successfully by Ips emarginatus, and to a less degree by D. monticolae and D. valens, resulting in higher populations of these species in 1941.

The increase in the populations of Ips emarginatus may not be without some effect on the D. brevicomis populations. Observations in the autumn of 1941 showed the Ips species following in numbers immediately behind the new Dendroctonus infestations. By their activities of appropriating and enlarging the egg galleries of the D. brevicomis, and in mining the surrounding phloem, it would seem probable that they are an important factor under such conditions in destroying the eggs and young larvae of the primary species. In this way the Ips might markedly affect the establishment of new Dendroctonus broods. Other observations of previous years have noted this phenomenon also (5).

Melanophila gentilis had an uncertain occurrence in both years. In 1940 Melanophila larvae considered to be M. gentilis, were found as secondaries in two trees. In 1941 larvae of a Melanophila, apparently M. gentilis also, were found to have initiated an attack in one tree.

Ips oregoni was found both years as a secondary species filling in the green uninfested tops of trees attacked by D. brevicomis. In 1940 the species was present in 22 percent of the trees, in 1941 in 19 percent. Although the species failed to appear as aggressive in the autumn infestations, there was evidence of its local aggressive action during the summer of 1940.

Dendroctonus valens was present as a secondary in the autumn infestations of both years. Its occurrence in 1940 amounted to but 2 percent of the infested trees. In 1941, however, the species was relatively abundant and was found in 14 percent of the trees. During the summer a few trees were noted in which D. valens appeared to have been first in initiating attacks on the trees. The increase in the populations of the species in the current year appeared to be due to the same circumstances that favored building up of the infestations of I. emarginatus and D. monticolae. D. valens was active in filling in green uninfested areas of the lower boles of trees partially attacked by D. brevicomis.

Unknown causes: In 1940 one dying tree was found which contained no insect infestations. In 1941 two trees were found which were well advanced towards death before insect attacks occurred. Causes of the death of these trees were undetermined.

Common infestation types and species combinations

In 1940, 19 combinations of species occurred in the series of infested trees. In 1941, 34 different combinations were found. While these numbers of combinations seem large, they represent variations of a smaller number of infestation types. In 1941 the large number of individual combinations seemed related to the relative abundance of D. monticolae, I. emarginatus, and D. valens. These species occurred together and separately in various sequences with the Melanophila and D. brevicomis infestations. The general infestation types of both years are shown in Table 4.

Table 4. Infestation Types in Ponderosa Pines

Infestation Type	Number of Trees 1940	Number of Trees 1941	Percent of Total 1940	Percent of Total 1941
Db and Db-Misc.	19	11	35.2	30.5
Db-Io and Db-Io-Misc.	12	5	22.2	13.9
Mc and Mc-Misc.		3		8.3
Mc-Db and Mc-Db-Misc.	12	5	22.2	13.9
Mc-Da and Mc-Da-Misc.	5	4	9.3	11.1
Da and Da-Misc.	4	4	7.4	11.1
Io-Misc.	1	1	1.9	2.8
Mg-Da	-	1	-	2.8
Unknown	1	2	1.9	5.6
Total	54	36	100.0	100.0
Green Tops	13	3	24.1	8.3

In both 1940 and 1941 the D. brevicomis attacks, pure or accompanied with miscellaneous secondaries, were the most common type of infestation. There was a slight reduction in this type of infestation from 1940 to 1941. Again in both years the D. brevicomis - Ips oregoni and the Melanophila - D. brevicomis types were second in position, with slight reductions from one year to the next. Other infestation types make up smaller percentages each year, but it will be observed that these show increases in the current season. Of interest is the occurrence of green, unattacked tops in the infestation, a condition generally regarded as an indication of a slowing down and tapering off of the infestation. It will be noticed that in 1940 24 percent of the trees had uninfested tops, apparently presaging the actual reduction in the bark beetle infestation that took place the following season.

Jeffrey Pine

Because of the small number of Jeffrey pine trees that were felled, a detailed study of their infestation characteristics will not be made. Five insect species were found attacking Jeffrey pine -- Dendroctonus jeffreyi Hopkins, Melanophila californica, Ips oregoni, Ips emarginatus, and Dendroctonus valens. The first two species were primary for the most part in the sequences of attacks. The remaining species were all secondary, occurring in small numbers only. Melanophila californica appeared to be primary in four of the thirteen trees. Dendroctonus jeffreyi was present in all trees, and primary in nine.

An abnormal infestation condition

In 1941 one newly infested four-tree group was felled for composition analysis. The group consisted of three Jeffrey pines and one ponderosa pine growing close together. In one Jeffrey pine D. brevicomis was found attacking all along the bole. Some parent adults were successfully making egg galleries, but most of the adults were killed just as they entered the phloem. The tree was successfully attacked also by D. jeffreyi.

When the ponderosa pine of the group was felled, a reverse condition was found. In this tree, in addition to the successful and heavy D. brevicomis attacks, a few D. jeffreyi were found attacking also. Most of the D. jeffreyi attacks were unsuccessful, but a few short egg galleries had been started, and in one case oviposition had taken place.

Such confusion in the selection of hosts by these species of beetles is of uncommon occurrence.

OTHER INFESTATION RELATIONSHIPS

Differences in species occurrence between single trees and trees forming parts of groups

If one compares the primary occurrence of species in single trees and in trees from groups, certain differences are observable, as may be seen in Table 5:

Table 5. Primary Occurrence of Insects in Single Trees and Trees Forming Parts of Groups (in percents of total)

	1940		1941	
Species	Single Trees	Group Trees	Single Trees	Group Trees
D.b.	36.4	71.9	25.0	83.3
M.c.	36.4	28.1	45.8	8.3
D.m.	18.2	-	16.7	-
I.e.	4.5	-	-	8.3
M.g.	-	-	4.2	-
Unknown	4.5	-	8.3	-
Total	100.0	100.0	100.0	100.0

Melanophila californica was found more often in the single trees than in the trees of groups. From 1940 to 1941 the species showed an increase in the single trees and a decrease in the group trees.

Dendroctonus brevicomis appeared more often in group trees than in the single trees. It suffered a decrease in the single trees from 1940 to 1941, and showed an increase in the group trees in the same period.

Dendroctonus monticolae was a primary species only in the single trees. There was little change in the occurrence during the two years.

Other species, Ips emarginatus, Melanophila gentilis, and unknown causes had a sporadic occurrence.

Species relations of the "key" trees of groups

Repeated observations suggest that group infestations often result from a concentration of beetles around a single tree of decadent condition. If the beetle population is high and other trees are in close proximity to the decadent tree, the infestation may tend to spread into the adjacent trees, forming a group infestation. In the course of cutting trees from groups during composition studies, several cases were found in which certain trees appeared to have served as centers, or "keys", for the development of multiple-tree infestations. Of the nine key trees felled in 1940 and 1941, eight carried Melanophila attacks which had preceded the attacks of D. brevicomis. The ninth tree succumbed directly to a D. brevicomis attack.

With respect to topkilling, five of the nine "key" trees were previously topkilled. Melanophila infestations appeared to have been responsible for the topkilling in two trees, and unknown causes were responsible for the remainder. Of the trees without topkills, M. californica was primary in all four.

Primary occurrence of species in trees with previous topkills and in trees without topkills

Trees that have suffered topkilling injuries sometime prior to the year of death often make up a fair proportion of the insect loss (3). It is of interest to inquire whether such trees suffer attacks from the different species in the same proportions as do the trees without topkills. Such comparison is made in Table 6.

Table 6. Primary Occurrence of Species in Relation to Topkilling (in percents of total)

Species	1940		1941	
	Topkilled	Non-topkilled	Topkilled	Non-topkilled
M.c.	60.5	20.5	46.2	26.1
D.b.	26.7	69.2	30.8	52.2
D.m.	13.3	5.1	7.7	13.0
I.e.	-	2.6	7.7	-
M.g.	-	-	-	4.3
Unknown	-	2.6	7.7	4.3
Total	100.0	100.0	100.0	100.0

From Table 6 it would appear that Melanophila californica has a greater association with previously topkilled trees. Dendroctonus brevicomis is associated more often with trees without previous topkilling. Dendroctonus monticolae seems to occur more often in trees without topkilling. Other species and causes occur irregularly. Some changes in the percentages of occurrences of the different species appear to have taken place from one year to the next.

SUMMARY

Results of composition studies in the Lassen National Forest in the seasons of 1940 and 1941 are presented and discussed. For the purpose of the studies 54 infested ponderosa pines were felled and analyzed in 1940. In 1941 36 ponderosa pines and 13 Jeffrey pines were felled and examined. The following observations were made:

1. A reduction in the number of infested trees was found in the fringe forest in 1940. In the interior forest of better site quality, however, the infestation remained high.

2. In 1941 a general reduction in the infestation was found over all the forest area.

3. Grouping tendencies were much lower in 1941 than in 1940.

4. There was but little difference in the average size of the infested trees in the two years.

5. In 1941 topkilled trees made up a larger proportion of the total number of infested trees examined than in 1940.

6. Dendroctonus brevicomis Leconte was the most frequent species in the infestations in both years.

7. Melanophila californica Van Dyke was the second most frequent species in the two years.

8. Dendroctonus monticolae Hopkins, Ips emarginatus (Leconte), Dendroctonus valens Leconte, and Ips oregoni (Eichhoff) were of common occurrence in the infestations, the first three species being relatively more numerous in 1941 than in 1940.

9. Jeffrey pine was infested with Dendroctonus jeffreyi Hopkins for the most part, although Melanophila californica appeared to have initiated attacks in four trees. Ips emarginatus, Ips oregoni, and Dendroctonus valens were present in the infestations also.

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